DOCUMENT RESUME

ED 455 244 SP 040 173

AUTHOR Ambrose, Rebecca
TITLE Catalyzing Change in Preservice Teachers' Beliefs: Effects of the Mathematics Early Field Experience.
SPONS AGENCY National Inst. of Child Health and Human Development (NIH), Bethesda, MD.; National Science Foundation, Arlington, VA.; Office of Educational Research and Improvement (ED), Washington, DC.
PUB DATE 2001-04-00
NOTE 33p.; Paper presented at the Annual Meeting of the American Educational Research Association (Seattle, WA, April 10-14, 2001). Supported through the Interagency Educational Research Initiative.
CONTRACT G00002211
PUB TYPE Reports - Evaluative (142) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Attitude Change; *Beliefs; Elementary Education; Elementary School Teachers; Higher Education; *Mathematics Education; Preservice Teacher Education; Problem Solving; *Student Teacher Attitudes; Student Teachers
IDENTIFIERS *Early Field Experience

ABSTRACT

This case study examines a program which catalyzed changes in preservice teachers' belief about mathematics and teaching, blending subject matter learning with learning about teaching early in preservice teachers' programs. It hypothesized that undergraduates who explored mathematical problem solving with children would be reoriented to mathematics, thus engaging in university mathematics coursework from a meaning making perspective. Preservice teachers taking their first mathematics course were placed in elementary schools to work with individual children. Activities were centered around mathematical problem solving to elicit children's thinking and make their mathematical understanding apparent. After meeting with children, student teachers convened to reflect on the experience. Data from field notes, surveys, interviews, and written work indicated that the case study student teacher's beliefs about children's confidence became connected to her beliefs about mathematics. She developed a new belief that children do not always learn what is taught. This belief was elaborated when added to the notion that teachers should listen to children to determine when to begin instruction. The student teacher discovered that the work of teaching was more complicated than expected, her deep knowledge in mathematics was important, and the work of caring was more complex than she had anticipated. (Contains 20 references and 2 figures.) (SM)

Reproductions supplied by EDRS are the best that can be made
from the original document.

ED 455 244

CATALYZING CHANGE IN PRESERVICE TEACHERS' BELIEFS: EFFECTS OF THE MATHEMATICS EARLY FIELD EXPERIENCE

Rebecca Ambrose, San Diego State University

Paper presented at the Annual Meeting of the American Educational Research Association, Seattle, WA., April 2001.

This work was supported through the Interagency Educational Research Initiative (IERI) Grant G00002211. Any opinions expressed herein are those of the author and do not necessarily reflect the views of IERI.

Please do not cite or quote without permission from the author.

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY

R. Ambrose

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

1

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

SP040173

BEST COPY AVAILABLE

Catalyzing Change in Preservice Teachers' Beliefs: Effects of the Mathematics Early Field Experience

Elementary school teachers' lack of mathematical content knowledge continues to be a great concern among mathematicians and mathematics educators. Ma's (1999) recent book documenting American teachers' lack of what she called Profound Understanding of Fundamental Mathematics has received a great deal of attention. Teachers need this knowledge to teach in the way advocated by the National Council of Teachers of Mathematics (NCTM, 2000) in *Principles and Standards for School Mathematics*. If teachers are to help children construct understanding of mathematics, they must be able to determine what mathematical knowledge the child already has. This assessment can be particularly difficult because children tend to have different pieces of mathematical knowledge. In other words, when a student in the teacher's classroom has a kernel of mathematical understanding, the teacher must be able to identify this understanding as a viable starting point for instruction. To make matters more difficult, the teacher needs to orchestrate discussion such that the different kernels that various individuals may have become accessible to the other children in the class. Ball (2000) described the knowledge needed to orchestrate such discussions as "the capacity to deconstruct one's own knowledge into a less polished and final form, where critical components are accessible and visible" (p. 245).

Unfortunately, despite having taken several mathematics classes and at least one mathematics methods class, most preservice teachers leave their teacher-preparation studies lacking such knowledge. One reason preservice teachers do not develop this knowledge base is that their beliefs about mathematics orient them to treat their course work as an exercise in memorization rather than as a meaning-making experience. Even when their course work is designed to promote sense making, preservice teachers do not always benefit, because their beliefs about mathematics limit their engagement with the course material. This paper is about an effort to reorient students to mathematics during their first college-level mathematics course.

That this reorientation occurs early in the students' course taking is important so that they will benefit from other mathematics courses they take, enabling them to develop the mathematical understanding necessary to be teach in the way described above. I will examine a case study of one student participating in this effort, known as Integrating Mathematics and Pedagogy(IMAP), to theorize about how the experiences of IMAP serve to reorient the students.

When we, the IMAP researchers, have considered reorienting preservice teachers to mathematics, we have hypothesized about the beliefs that might grow out of their IMAP experiences, beliefs that would lead them to approach mathematics from a meaning-making perspective. We think that one of the most important beliefs to foster is the belief that mathematics involves a web of interconnected concepts and procedures. Related to this belief are several beliefs about the relationship between concepts and procedures: that knowledge of concepts is more powerful and generative than knowledge of procedures and that one can know procedures without understanding the underlying concepts. If preservice teachers begin to appreciate the importance of concepts in developing mathematical understanding, they will begin to approach their course work by trying to develop conceptual understanding rather than by memorizing a technique for a test (see Figure 1 for a model of this belief system).

The other beliefs that we would like to foster are related to teaching and learning mathematics. We hope that preservice teachers come to believe that children bring to school a great deal of informal mathematical knowledge that can be the basis of instruction and also that sometimes the ways children do mathematics differ from the ways of adults who have been schooled. These beliefs are related to the ideas, mentioned above, of looking for kernels of students' understanding of mathematics. These beliefs will affect preservice teachers' approaches to their mathematics course work by helping them recognize that their knowledge of mathematics needs to be extensive enough so that they can look at problems from multiple standpoints. The preservice teachers will realize that children have a variety of ways of thinking and that the preservice teachers' knowledge of mathematics must enable them to make sense of these diverse approaches. They have to be prepared to see the legitimate emergent mathematics

in various approaches as well as the misconceptions or overgeneralizations that may be underlying a child's technique. Before they can develop this kind of mathematical knowledge, preservice teachers must believe that building on children's informal knowledge is a worthwhile endeavor.

How do we nurture this idealized belief system in our preservice teachers? Before describing the IMAP program and the ways it theoretically will reorient preservice teachers to mathematics, I will establish the framework I have adopted to think about the process of belief change that will result in the preservice teachers' becoming reoriented to mathematicsThis framework rests on some theories about beliefs: where they come from, the effect they have on individual's interpretations of experiences, their functions in decision making, and the ways separate beliefs combine to create belief systems. After establishing a way of thinking about beliefs, I will consider how beliefs can change within this framework.

Belief Systems

Sources of Beliefs

Beliefs have one of two sources: emotion-packed experiences and cultural transmission (Pajares, 1992). The first source, emotion-packed experience, gives beliefs their "signature" quality. Many people can point to a particular vivid memory from which a particular belief emerged (Nespor, 1987). For example, some preservice teachers give detailed accounts of crying while they struggled to learn their multiplication tables. They relate these experiences to their belief that they are incapable of learning mathematics. One could say that these kinds of experience-based beliefs are what have been called evidentially held beliefs (Green, 1971). These are beliefs that are justified by some sort of evidence from the real world. The emotional component of the experience is one feature that differentiates beliefs from other forms of knowledge. In relating this feature to beliefs about teaching, Goodman (1988) suggested that beliefs about teaching were derived from guiding images based on both positive and negative experiences that teachers had as children.

The second source of beliefs, cultural transmission, creates beliefs that may be held at a subconscious level. These are beliefs that individuals develop as a result of living in their cultures, their families, and their schools. These beliefs can be thought of as the learning that results from the "hidden curriculum" of our everyday life and can take the form of assumptions and stereotypes. Because most of their work in school has involved memorizing procedures, some preservice teachers assume that mathematics always involves memorization, even though they have never heard such a statement. People are often unaware of the culturally transmitted beliefs they hold, taking them for granted because they have never examined or discussed them. These beliefs are typically not justified in terms of real-world evidence or intense personal experience. These implicit beliefs may guide behavior in ways that could be characterized as habits, with individuals doing things in particular ways of which they are hardly cognizant (see Figure 2).

Effects of Beliefs

Beliefs have a filtering effect on new experiences that the individual encounters (Pajares, 1992). This filtering effect can make beliefs quite durable; the effect is evident when preservice teachers do not interpret experiences or information in their courses in the ways that their instructors intended (Simon, Tzur, Heinz, Kinzel, & Smith, 2000). For example, one colleague of mine had her methods students work with kindergartners during the second week of school. She designed an activity centered on story problems. Her intention was for the preservice teachers to realize that young children come to school with a great deal of informal knowledge. After this field experience, the preservice teachers returned to class impressed with how much the teacher had taught the children in the first week of school (personal communication, L. Clement, Jan. 2001). Their belief led them to interpret the experience as evidence of teaching rather than of the children's informal knowledge. It is this powerful filtering effect of beliefs that makes them play such an important role in learning.

Beliefs serve an important cognitive function at the level of choosing problems and tasks on which to focus. Nespor (1987) discussed this function in terms of the messy domains in which

teachers have to make decisions. Even before they develop a strategy for dealing with a problem, teachers have to decide on which problems of practice they are going to focus. Their beliefs about schools, teaching, and children orient them to focus on particular problems rather than others.

Belief Systems

Beliefs, whatever their source, are related to one another, forming belief systems in which related beliefs are connected to one another (Rokeach, 1968). The more connections a particular belief has, the more central it is in the system. Some clusters of beliefs exist with no connection to other clusters in the system. For example, some preservice teachers believe that children should have opportunities to be creative, and this belief might be connected to other beliefs about art and writing. This belief may come from their own creative childhood experiences in these domains. The belief about the importance of creativity may not be connected to beliefs about mathematics, because the preservice teachers have never had creative experiences in mathematics and assume that having such experiences is impossible. Their beliefs about mathematics are separate from their beliefs about the importance of creativity for a child's development.

Green (1971) pointed out that belief clusters may be held in isolation such that they are not connected to other belief clusters. He wrote, "We tend to order our beliefs in little clusters encrusted about, as it were, with a protective shield that prevents any cross fertilization among them or any confrontation between them" (p. 47). When these isolated beliefs are activated by the same situation, the believer can become unsettled by the apparent inconsistency in her beliefs. For example, a teacher might believe that having children figure things out for themselves is important. She might also believe that she needs to prepare her students to do well on the standardized tests that are the currency of academic success in our culture. She knows that one key to success on these tests is quick calculation with the most efficient algorithms available. These two beliefs can lead to very different forms of instruction, leaving the teacher feeling unsettled when she chooses one or the other, because she is not acting in concert with all her

beliefs. Green suggested that education involves helping people develop well-connected belief systems to eliminate such inconsistency.

Related to the idea that beliefs exist in connected clusters is the idea that some isolated beliefs are also peripheral beliefs (Rokeach, 1968). These beliefs could be likened to stereotypes in that they are not differentiated. These isolated beliefs are typically beliefs that, being based on assumptions that have been culturally transmitted, have not been examined.

Changing Belief Systems

Growing out of this framework for thinking about beliefs are several avenues for change. First, beliefs can be brought into the open and examined. With this kind of consciousness raising, one could examine inconsistencies so that beliefs might become more coherent and better aligned; in examining their beliefs, individuals consider the decisions they make and the beliefs that drive those decisions. This process helps them to make more principled decisions on the basis of beliefs they believe are important, rather than acting on the basis of the habits of unexamined beliefs. Consciousness raising in the form of reflective practice is at the heart of many teacher education programs. Fenstermacher (1979) pointed out that the role of teacher education programs should be to support teachers in bringing tacit beliefs into the open so that these beliefs can be transformed into objectively reasonable beliefs.

Another way that belief systems can change is for connections to be made among beliefs; for example, as discussed earlier, one's beliefs about mathematics and beliefs about children's creativity might be connected. In connecting previously unconnected beliefs, one will activate new beliefs in situations in which they might not previously have been activated. Individuals will come to see new possibilities not recognized before in a given situation.

A more dramatic way that a belief system might change is for a new belief to develop. This new belief would be connected to existing belief clusters and would be an elaboration of the existing system. For example, the student who believes that she cannot learn mathematics because she struggled with multiplication tables might have an experience solving a difficult problem on her own. This vivid and emotionally packed experience might lead her to believe that

she can solve some mathematics problems; the experience would be connected to her existing beliefs about herself and mathematics. Note that I am not suggesting that her original belief about herself and mathematics would cease to exist. Nothing could erase the vivid memory from which it came, and so it would remain in her belief system. This new belief that she can do some mathematics would become connected to her previous belief about herself and mathematics, enabling her to cautiously try problems she might have completely avoided in the past.

The most dramatic belief change is the reversal of existing beliefs. For example, the revolutionary change in religion and science from people's believing that the Earth was at the center of the universe to their believing that the sun was at the center of the universe was this kind of belief reversal. This kind of conversion is rare, as Kuhn (1996) discussed in the context of the beliefs held by the scientific community; he noted that in a paradigm shift, one way of thinking gets replaced by a new way of thinking.

Summary of Belief System Theory

In summary, some beliefs grow out of emotionally charged experiences that leave behind vivid images. Beliefs can also result from the subtle effects of cultural transmission. Beliefs help individuals make judgments and choose the tasks to which they will direct their efforts. In serving this filtering role, they also affect people's interpretations of new experiences.

Beliefs are connected to one another, forming clusters. These clusters can change when new connections are made among beliefs and when beliefs become more refined. These changes can result when one reflects on beliefs and considers decisions made and actions taken. Changes can also arise from an emotion-packed experience unlike any the individual has had before. This experience creates a vivid, memory–based belief, and the new belief becomes integrated into the person's existing belief system. Finally, when a core belief is reversed, one's whole system can change radically if all the beliefs connected to this belief have to accommodate this reversal.

Belief System Change in Preservice Teachers

Starting from this framework for thinking about beliefs and how they may change, I will now consider teacher education and the kind of changes one might be able to engender in

preservice teachers. Often teacher educators aim for the most radical form of belief change: conversion or paradigm shift. They try to cultivate a reversal of beliefs and are left having failed not only to convert their students to new beliefs about teaching and children but also to promote their learning about teaching. These disappointments have been well documented, leaving Wideen, Mayer-Smith, and Moon, (1998) to suggest that teacher educators might attempt to build on preservice teachers' existing beliefs rather than tear them down. In IMAP, we share this goal of building on preservice teachers' beliefs.

To build on preservice teachers' beliefs, one must recognize that their beliefs about mathematics reside within a larger system of beliefs about teaching. Weinstein (1990) found that preservice teachers place strong emphasis on affective and interpersonal issues because they believe that the most important aspects of a teacher's work are connecting with children, providing them with safe environments in which to learn, and giving them positive attention. Their belief in the importance of teacher as nurturer leads preservice teachers to discount the importance of subject-matter knowledge. Beliefs about the importance of relationship building endure into the first years of teaching when new teachers often expend a great deal of energy trying to find ways to develop positive relationships with children (Hollingsworth, 1992).

Goldstein and Lake (2000) examined this caring orientation of preservice teachers and found that the beliefs about the importance of caring for children grew out of vivid childhood memories and cultural transmission. They cited the many cultural images of good teachers as being kind and friendly and of bad teachers as mean and hard-hearted. They suggested that these cultural images led preservice teachers to hold stereotypic beliefs, that is, beliefs that were undifferentiated and disconnected from other beliefs about teaching. They characterized these beliefs as partial, underdeveloped, and oversimplified.

Another belief that many preservice teachers hold is that teaching involves presenting information. After having watched teachers provide explanations most recently at the university, they assume that explaining is a fairly straightforward enterprise (Feiman-Nemser, McDiarmid,

Melnick, & Parker, 1988). Simply stated, preservice teachers believe that teachers should be nice and should present instruction clearly.

If one rejects the premise that we teacher educators can convert preservice teachers to whole new ways of thinking about teaching, then these beliefs about teaching as caring and teaching as explaining are the foundations on which we have to build. We must assume that preservice teachers will continue to hold these beliefs while their belief systems change and develop. These beliefs may become connected to new beliefs or become connected to old beliefs in new ways. All indications are that these beliefs will endure while preservice teachers engage in their course work and student teaching. I suggest that we can take advantage of these beliefs as a starting point in our work with students.

In the following case study, I will consider an intervention program designed to catalyze changes in preservice teachers' systems of beliefs about mathematics and teaching. I will consider the program elements that served to reorient the participant to mathematics and teaching. I will then return to the types of belief change outlined earlier to consider which kinds of change occurred for this student. I intend to show that building on preservice teachers' beliefs about teaching is a viable enterprise; in particular, I plan to show that preservice teachers' beliefs about the importance of caring can serve as the foundation for reorienting preservice teachers to mathematics.

Case Study

Description of Intervention

The intervention was an effort to blend subject-matter learning with learning about teaching early in preservice teachers' time at the university. The hypothesis upon which the intervention was based is that undergraduates who explore mathematical problem solving with children will be reoriented to mathematics so that they will engage in their university mathematics course work from a meaning-making perspective.

In the intervention, called the Mathematical Early Field Experience (MEFE), preservice teachers who were taking their first mathematics course were placed in an elementary school

setting where they worked with individual children eight times; activities with the children centered around mathematical problem solving. The MEFE was considered a course and met for 2 hours, once a week. Fifteen students were recruited for the course before the semester began and were compensated for their participation. Typically the preservice teachers met with their instructor for a half hour to review the problems they would be doing and to anticipate issues that might arise. They then worked with children for 45 minutes and returned to the group of preservice teachers to discuss and reflect on the experience.

The preservice teachers were given specific tasks and activities designed to elicit children's thinking and to make the children's mathematical understanding apparent. The emphasis was on problem solving rather than symbol manipulation. The preservice teachers had opportunities to work with various manipulatives and hand-held computers to support the children in making sense of the ideas.

Each preservice teacher worked with a partner; one in each pair led the problem-solving session, and the other took notes. The partners were encouraged to help each other, and during the session with the child, they often exchanged ideas about which problem to do next, what question to ask, and so on. The partners could reflect on the experience afterward and consider issues that arose in the interview.

During the first weeks of the course, the preservice teachers worked with primary-grades children. The goal in this phase of the MEFE was to acquaint the preservice teachers with children's problem-solving abilities. This part of the intervention was designed to influence the preservice teachers' beliefs about children's informal knowledge and their tendencies to act out story problems. During these first weeks, the preservice teachers worked with a different child each week.

During the last 4 weeks of the course, each pair of preservice teachers worked with one fifth-grade child on fraction concepts. This part of the intervention was designed to show that a concrete approach to this difficult concept can help children develop understanding. We, the IMAP staff, expected that many of the children would have difficulties, particularly in making

sense of the symbolic aspects. We hoped that the preservice teachers would come to see that real-world contexts and careful use of drawings and manipulatives would help them in teaching the children.

The MEFE was in a pilot stage at the time of this study. Before conducting the large-scale, quantitative study, we were perfecting the design of the course and several research instruments that were to be used as part of that larger study. We were interested in determining what individuals got from the course and how they interpreted their experiences. The large-scale study will provide evidence for the effectiveness of the MEFE whereas this pilot study was designed to provide evidence for why the MEFE is effective.

We elected to focus on an individual student to consider the following questions:

- Did the student develop the beliefs that we hoped she would?
- What about the experience contributed to the change? What is the power of preservice teachers' working with individual children in problem-solving environments?
- How did the student interpret her experience? What stood out to her?
- Which of the four previously identified kinds of belief-system change, from consciousness raising to paradigm shift, were applicable to this student?

Participant Selection

The IMAP researchers used purposeful sampling (Yin, 1994)) to select five participants for case studies. We wanted to follow students who had the most to gain from the MEFE, that is, students who initially held the most traditional beliefs. We also wanted to follow students who differed in terms of both their comfort with mathematics and their demographic characteristics. We identified several students with traditional beliefs and from that group chose two who reported being anxious about mathematics and displayed minimal mathematics understanding and two who reported comfort with mathematics and displayed competence with standard algorithms. We also chose one student who seemed to be between these two extremes.

In this analysis, I will limit the focus to one student to consider ways in which the MEFE experience catalyzed changes in her beliefs. I selected a student who did not fit the stereotype

that mathematics educators tend to hold about PSTs. In my own teaching I had been challenged by students who had been successful with mathematics as children and were procedurally competent. There was little in the literature to guide my work with these students because the research literature focused on students who were not successful with elementary school mathematics and did not like it. I chose to focus on a student who had mastered the procedures of elementary mathematics so that I could not only understand the MEFE and its potential as a catalyst for change but also to better understand procedurally competent PSTs.*Data Sources and Analysis*

Data sources included field notes, belief surveys, interviews, and the preservice teachers' written work. We collected data during the MEFE, during the mathematics course in which the preservice teachers were concurrently enrolled, and through interviews with the participants. Each student in the MEFE completed a computerized belief survey before and after the semester.[1] The case-study participants were interviewed five times during the semester: once as a follow-up to the initial administration of the belief instrument, once to get their impressions of the mathematics course, twice to debrief them on their MEFE experiences, and once at the end of the semester to capture their final thoughts.

During the mathematics class, field notes were collected from three observers. One observer kept track of the flow of events in the class, and two observers focused on individuals. We attempted to document the level of participation of the students as well as the material that was covered. Copies of homework and tests were also used to document the learning of the participants.

Field notes were taken during the MEFE class discussion and during preservice teachers' work with children. Each preservice teacher in the MEFE was videotaped once while she or he led the problem-solving sessions with a child. These data were used to determine whether the preservice teachers focused on concepts or procedures in their work with the children. They were

[1] Information about the belief survey can be found at http://CRMSE.sdsu.edu/IMAP

also used to determine the degree to which the preservice teachers followed the script of the activities they were given. After each problem session, the preservice teachers wrote "quick-writes" in which they shared their initial impressions; they wrote longer reflections as homework. Finally, informal conversations between researchers and preservice teachers formed another source of data.

The case study was primarily instrumental (Stake, 1995) as the intention was to understand the MEFE and its effects rather than to understand all of the beliefs of the case study participants. These data were coded using two sets of codes: One set related to the ideal beliefs that the intervention was designed to nurture; the other involved those issues that the preservice teacher raised when she interpreted her experience. Memos (cite) were produced during the semester to capture the preservice teachers' growth. While coding progressed and themes emerged, data were revisited when the researchers looked for confirming and disconfirming evidence of hypotheses. The research team consulted during data collection to confirm impressions of the participants and their participation in the mathematics class and the MEFE.

Description of Case-Study Student

Donna was a transfer student who had spent her first two years of college at a community college. She participated in the IMAP project during her first semester at the university. She reported that she had enjoyed mathematics as a child and had been successful in it. She was an active class participant, responding to questions from the instructors, asking questions of her own, and volunteering her mathematical thinking when appropriate. She reported that she felt comfortable in the class and never hesitated to participate. She particularly appreciated the personal interest that the instructors took in the students.

Beliefs at the Start of the Semester

At the start of the semester, Donna had a few of the beliefs that we were hoping to foster. She had some faith in children's abilities to derive answers to problems on their own. On the initial belief instrument she responded that first graders would be able to solve a multiplication story problem by building the groups with blocks and counting the total. She showed interest in

children's approaches and could describe the details of what they could do. For example, after completing homework for which she watched videotape of children solving story problems, Donna noted that the child had built numbers using tens and ones and had counted his result by twos. This level of detail was unusual inasmuch as other students tended to talk only about whether children's answers were correct.

Donna's beliefs about children's mathematical knowledge were not related to her beliefs about procedures and concepts. She thought that standard algorithms were the best way to solve problems and assumed that children who performed them had good understanding. She was not interested in alternative approaches to the standard algorithm, dismissing such approaches as unworthy of her attention. Her comments about alternative approaches included, "It just seems difficult and way too beyond what is really necessary."

Two beliefs emerged from the data that were of particular importance to Donna. A few of Donna's statements in her first interview indicated that she held a "teaching as telling" orientation. When asked what she thought she might learn from her mathematics course, Donna responded,

> Actually, I feel pretty comfortable being able to teach mathematics to children already. Maybe just different ways than I'm used to so that kids if they don't get it one way, I can tell them a different way, or show them. (initial interview)

When, in the same interview, she was asked which of several addition strategies she would like for children to share with their classmates, Donna, assuming that the teacher would show the strategies; stated, "Also, when showing kids that way, that's the easiest to show." She was asked several questions related to these addition strategies, and, throughout, she continued to assume that she as the teacher would be showing the strategies, even though the emphasis in the question was on the strategies being shared the children who generated them. Even when, at one point, she was reminded that she would not necessarily be teaching these strategies, she continued to assume that she would. Although we did not set out to directly assess a belief about teaching as

telling, we infer from the way Donna responded to questions that she, like many preservice teachers, held this belief.

Although we did not gather data relevant to this belief at the start of the semester, we assume that Donna shared the belief that teaching is nurturing, a belief that other researchers have found to be common among preservice elementary school teachers (Weinstein, 1990, Goldstein & Lake, 2000). She told us that she intended to be a kindergarten teacher because she loved little children so much. She had also worked extensively with children during and after high school. She made no statements that caused us to question our assumption that Donna believed in the importance of teachers' being kind and developing positive relationships with their students.

To summarize, Donna believed that children could come up with novel solution strategies to mathematics problems and that children had mathematics experiences before coming to school. She did not believe that mathematics was an interconnected web of concepts and procedures, instead she thought that the efficient execution of standard algorithms was the focal point of mathematics. She seemed to have the beliefs that teaching involves explaining things to children and being nice to them.

Significant Experiences in the MEFE

Donna's four sessions with her fifth gradestudent, Belinda, left a large impression on her. The focus of this work was to explore, using the pattern blocks, relative sizes of fractions and different names for fractions greater than 1. Donna also asked Belinda to solve equal-sharing problems that resulted in mixed-number answers and to explore mixed-number representations on hand-held computers. The tasks were designed to build conceptual understanding and to deemphasize the symbolic work that often leads children to misconceptions (Mack, 1995).

In their first session, an assessment with Belinda, Donna and her partner found that Belinda was relatively unfamiliar with fractions. The second session was a high point for all involved. Belinda seemed to enjoy working with the pattern blocks and was able to build representations for a variety of fractional quantities. Because she was so successful, Donna and her partner had

her work a few problems involving number symbols, converting improper fractions to mixed numbers. She successfully converted five mixed numbers with some prompting from Donna and her partner. Donna was enthusiastic about the experience:

> Our interview with Belinda went surprisingly well. I was so stoked as we taught her how to do mixed numbers and improper fractions and she picked up on it and was able to write her own. She even was able to do 23/12 into 1 11/12 and 10/4 into 2 2/4. I was amazed. (Quick-write response immediately after the interview with Belinda)

> Belinda's knowledge grew tremendously.... Belinda flew through [Problems] a–d.... Belinda whizzed through [Problems] a–c. (Formal interview write-up)

The enthusiasm surrounding this episode was due in part to the child's attitude. Belinda was relaxed and happy while she worked with the blocks. She was able to respond to questions and generate answers on her own, without much help. From Donna's perspective, Belinda was figuring things out for herself. The only point at which Belinda expressed doubt was when the students gave her problems she could not solve with blocks. By the end of the session, Belinda was able to successfully convert improper fractions to mixed numbers without the aid of pattern blocks. Donna was excited because she believed that she had taught Belinda something.

The follow-up session was a let down for Donna. Instead of starting with equal-sharing problems (the MEFE plan for the day), Donna and her partner began with symbol-based conversion problems. Belinda was unable to symbolically convert 7/6, 9/6, or 13/12 into mixed numbers without significant help. Belinda was successful at solving problems situated in story contexts about children sharing cakes and cookies. She worked each sharing problem in several different ways, using drawings.

In her writing and conversations in class, Donna focused on Belinda's struggles with the number symbols. Her comments included

> Belinda had forgotten much of what was taught her from the last time. ... She was more confused than anything else today. (Quick-write response)
> That was the hardest interview yet. It's hard when they don't get things. (Conversation)

> She was never really sure of herself today. She more played off N's [Donna's partner] and my facial expressions, and if we made comments like "You're doing great," she would keep going, but if we made no comments or no smile or anything, she would erase her work and start over. I felt as though she didn't have any self-confidence. (Formal writing)

Donna's observations were consistent with my interpretations of the session, particularly her observation about Belinda's reading facial expressions. Donna was clearly discouraged that the previous teaching episode had not resulted in Belinda's remembering how to convert improper fractions to mixed numerals. Donna's focus on Belinda's struggle rather than on Belinda's success might be due to Donna's personal investment in Belinda's learning. Donna was excited by the teaching she thought she had done and became deflated when the learning turned out to be temporary. She gave the review problems because she had expected them to be easy for Belinda and was disappointed when they turned out to be quite difficult.

Growth Toward Ideal Beliefs

Donna's comments, at the end of the semester, about what she would tell other preservice teachers show that this episode had a great effect on her: "Well, like I said before, not to expect, that a child knows what you've taught 'em, because just because you've taught 'em doesn't mean that they understand it" (End-of-semester interview). We inferred from this comment that Donna originally did expect that Belinda would know what Donna thought she had taught her. After working with the child a second time, Donna realized that results of such work are not as predictable as she had anticipated.

Donna's reaction to the experience indicated that she was beginning to develop the belief that mathematical understanding develops slowly. At the start of the semester, she had shared with many of her classmates the assumption that children learn what they are taught, an assumption derived from the traditional mathematics curriculum delivered in most schools. Her experience in working with Belinda challenged this assumption and caused her to reexamine this belief.

Revision of Beliefs About Teaching

Donna's comment advising other preservice teachers not to expect that children will understand what has been taught indicated an elaboration of her beliefs about teaching in general. She articulated awareness that presenting information does not ensure that children will learn. Later in the interview Donna commented further:

> You have to make learning fun for children and relate it to the real world, and not drill it into their heads, but just give them their own (pause). . . . When children learn, they need their own space and time to learn on their own. Let them have a chance first, and then see what they need help with. (End-of-semester interview)

This comment illustrated an expanded view of teaching when Donna talked about assessing students' understanding before showing them what to do. She also mentioned giving students time to learn on their own. Her teaching experience has supported her in focusing on the learner more than on the teacher. Her beliefs about teaching became more elaborate than the limited view of teaching-as-telling that was apparent at the beginning of the semester.

Donna's beliefs about the affective components of teaching seem to have changed as well. In reacting to her MEFE experience, she focused on Belinda's lack of confidence. Donna repeatedly talked and wrote about Belinda's dependence on her for feedback. For example, she wrote

> It became all the more clear to us just how much Belinda relies on our comments and tone of voice. Belinda, we feel, doesn't really trust herself enough; she changes or keeps her original answer based on our comments and/or questions. (Formal interview write-up)

Her comments indicate that Donna, worrying that her teaching practices had interfered with the child's confidence, felt some dissonance. Other students in the MEFE shared similar concerns that they raised in group discussions of the children's work. The researchers also noted the children's dependence when they observed the interviews. The dependence was particularly acute when the preservice teachers attempted to teach the children symbolic procedures. Many students in the class shared the goal of having the children be autonomous learners and were

frustrated that their attempts at teaching were not fostering the autonomy they had hoped to promote.

This concern was evident when Donna responded to the question "What advice would you have for other students about to start the MEFE?"

> I say that it is good to give positive reinforcement, *but not too much, because a lot of times our girl grew dependent on what we would say* (italics added), and then if we didn't say, "Oh, great job, Belinda," then she would think she was doing it wrong. She kind of wasn't so sure of herself since we... well, I, a lot of times,... gave her a lot of positive reinforcement, and then it doesn't necessarily mean that she was sure. Sometimes even she would just be guessing, and I'd say, "Good job," and I didn't know she was guessing. Ya know, stuff like that. (End-of-semester interview)

Although Donna still advocated giving students positive reinforcement, she qualified this advice. Donna had given a great deal of indiscriminate praise in her initial interviews, and she realized that she was not always listening closely to what the child was saying. After Donna spoke about her realization, I reviewed the videotape of her interview with one of the primary children. In that interview, she had complimented the child once if he got the problem wrong and up to three times when he was correct—in these cases, she often complimented him while he was solving the problem, for example, "That was a good way to think . . . very good . . . excellent." In the third session with Belinda, Donna began to recognize Belinda's dependence on this praise and commented on it many times after that. After she had this realization, her compliments diminished in both number and emphasis.

Several times Donna expressed concern that Belinda did not have much self-confidence. Such comments indicate that Donna was beginning to wonder about the wisdom of providing the level of positive reinforcement she had provided. She still felt that providing praise was important, but she seemed to recognize that it might not lead the student to develop confidence. Her experience with Belinda cast some doubt on what was before a taken-for-granted assumption that teachers should be encouraging.

The structure of Donna's belief system began to change when she experienced the complexity of promoting autonomy. She developed the belief that children should be confident in their abilities to do mathematics and recognized that praise alone would not support the confidence that she hoped to promote. She began to see that the caring and nurturing work of teaching involves more than being supportive and, specifically, that she would need to be more careful in her use of praise. Her stereotyped belief about the importance of being nice became more elaborated when she noticed how dependent on her feedback the child had become. I hypothesize that by reflecting more, Donna would notice the kind of feedback that empowers rather than creates dependency, further elaborating her belief.

Beliefs That Did Not Change

Donna's experience in the MEFE affected some targeted beliefs and had farther reaching effects as well. However several beliefs we had hoped to affect remained relatively stable. I will now discuss these resilient beliefs.

Among the beliefs that we had hoped to nurture were beliefs about the relationship between concepts and procedures, particularly beliefs about the importance of focusing on concepts before teaching procedures, the generative power of concepts, and the potential for procedures to be executed automatically without one's understanding the related concepts. I found no evidence that these beliefs were part of Donna's belief system. This is particularly striking given that Donna was participating in a math course and the MEFE both of which were directed toward developing a conceptual orientation to mathematics. Her beliefs about concepts and procedures were limited to the belief that the standard algorithm is the best way to solve problems. This stance was evident at the start of the semester when Donna was asked to compare two subtraction approaches, the standard algorithm, which was called Lexi's approach, and the following sequential approach, which was called Ariana's approach:

Ariana:
635 – 400 = 235
235 – 30 = 205
205 – 50 = 155

$155 - \underset{482}{2} = 153$

Ariana says, "First I subtracted 400 and got 235. Then I subtracted 30 and got 205, and I subtracted 50 more and got 155. I needed to subtract 2 more and ended up with 153."

In comparing the two approaches, Donna observed

> Lexi's approach is very straightforward. Ariana's, on the other hand, is extremely confusing. It seems as though she doesn't possess basic math skills. … Her approach makes no sense at all. … I think she made it a lot more difficult than it really needs to be. (Start-of-semester belief survey)

Donna made similar comments when she looked at other collections of approaches, always preferring the standard algorithm and not looking very closely at alternative techniques. Her comment that Ariana's approach was "a lot more difficult than it really needs to be" was repeated often when she examined alternate approaches. Her perception seemed to be that school mathematics entailed students' producing answers to computations in the shortest possible amount of time. This view is consistent with the kind of teaching that she had undoubtedly experienced as a child.[2]

When Donna was asked to compare the same two subtraction approaches on the postsurvey, she continued to assume that children using the standard algorithm had better understanding than children using Ariana's approach. She wrote

> Lexi shows the greatest understanding because she seems to know more about grouping.… Both show the understanding of different mathematical concepts … all people learn differently and some approaches are easier for certain people than others.

This response indicates that Donna was now more willing to accept Ariana's approach as a viable alternative to Lexi's. However, she considered it as a back-up for the standard algorithm.

---

[2] Her comments are particularly troubling to mathematics educators because we would like teachers to be able to scrutinize an approach like Ariana's to see if it is reasonable. At least, if a child is using an approach like this, we would like for the teacher to allow the child to continue using it, instead of dismissing it as nonsensical.

She did not see Ariana's approach as involving more conceptual understanding—as did some of her classmates.,not recognizing that the process of Ariana's would be easier to follow than the renaming involved in the standard algorithm, Donna assumed that children would be more successful using Lexi's approach.

Donna's faith in procedures was also evident in her mathematics course work. She was fluent in the arithmetic procedures for operating on whole numbers and fractions. She attempted to solve problems using drawings rather than algorithms but would readily give up when she had difficulty. Her final examination revealed that she had not mastered the ability to operate on drawings rather than number symbols. This result indicates that she did not embrace the belief that concepts are at least as important as procedures.

Donna's preference for symbolic manipulation was also evident in the MEFE when she focused on converting improper fractions to mixed numerals in symbolic form rather than focusing on the contextual problems that she had been encouraged to use with Belinda. In Fraction Session 3, Donna chose not to follow the MEFE directions for the day and instead chose to begin working on the symbolic manipulation that she and her partner had addressed with Belinda during the previous session. Donna did not believe that developing the concepts of fractions first was important; instead she focused on symbol manipulation.

The persistence of Donna's beliefs about the importance of symbol manipulation over conceptual understanding may be due to its cultural roots. Most curricula focus on the standard algorithms. Donna (and many of her peers) believed that content in these curricula or the textbook must be the best type to teach. She had faith that the curriculum her teachers had used had been organized around procedures that were the easiest to understand. Because she had been successful in learning the algorithms, she had no reason to question the curriculum and its emphasis on procedures.

That someone who had success with symbol manipulation would believe that symbolic manipulation was the center of mathematics is not surprising. Donna reported that she loved mathematics because she could "crank out" answers. Her work in the MEFE did alter this belief

at least a small amount. In the middle of the semester, she observed that she had never been curious about why things worked in mathematics but that after working with a child, she realized the importance of teachers' understanding "why" when they teach the material. We viewed this comment as minor evidence that Donna was beginning to believe that mathematics is a web of interrelated concepts and procedures. A great deal more evidence and reflection will be required for Donna to elaborate this belief.

Summary of Belief Change

Donna's belief system changed in two important ways, but much of the system remained intact. She developed the belief that in mathematics, children often need a variety of experiences with a topic to learn that topic. She revised her expectation that if something is taught well, then students will learn it. She expressed this view in the context of discussing her attempts to teach Belinda how to convert improper fractions to mixed numbers. Donna connected a belief about the importance of promoting confidence to her beliefs about teaching mathematics. She developed a keen sensitivity to her student's confidence level.

She did not change in all the ways we had anticipated that students might change. She began to think that concepts were important insofar as they are necessary to explain the workings of procedures. She did not adopt the perspective that concepts themselves merit attention.

Catalysts for Belief-System Change

I have reviewed Donna's experiences and her interpretations of those experiences and have hypothesized about changes in her belief system relative to the system that we in IMAP consider optimal. In this section I will revisit the ideas of the ways that belief systems evolve to determine how to account for the moderate changes that Donna experienced.

Focus on Mathematics Learning Rather Than on Classroom Management

The fact that Donna worked with an individual child was critical to the success of the MEFE as a catalyst for change. Because she was working one-on-one with the child, Donna did not face the cognitive overload that can accompany teaching. When preservice teachers are in student-teaching situations, they must attend to all the issues of class management *and* content.

Through her work with an individual child, Donna had clear evidence that the child was struggling and that her own teaching resources were not developed enough to help the child. Donna could concentrate her thinking on this issue because she was not distracted by the host of management issues that typically concern student teachers.

Also, Belinda's struggles were clear to Donna because she could focus on one child's learning rather than on the learning of several in the class. Donna had given the best explanations of which she was capable, and she knew that the child had heard the explanations. She could not attribute the failure to the child's behavior, attention span, or attendance. Nor did Donna have the option to turn to a different child to get the answers she sought; no other children could "bail out" Belinda or Donna. Both had to face the fact that this was difficult material to teach and learn.

High Cognitive Demand

Although in the MEFE, we strip away some of the extraneous factors that occupy teachers' minds, Donna had to think about several things while she worked with Belinda. She experienced what some call "knowledge in use" [e. Ball, 2000], that is, the knowledge that teachers must use in the "entangled domain" that is teaching. She had to consider the mathematical concept at hand. She had to attend to what the child was doing and consider what understanding the child had. She had to decide what question to ask or what problem to provide to extend the child's understanding. She had to decide what representation would help the child better understand the concept. Her cognitive capacity was taxed while she kept track of all of these issues.

The emphasis on problem solving in the MEFE created another cognitive demand on Donna. She could not resort to the kind of teaching she had probably experienced as a child. She knew that she was supposed to give the child opportunities to figure things out for herself. This constraint raised for Donna challenges that she had not faced before. She had to do her own problem solving while she tried to help Belinda, but she realized that her mathematical understanding was not deep enough to allow her to supply this kind of help. Donna resorted to

symbolic manipulation with Belinda because this was the content she knew best. For Donna, working with Belinda in the domain of pictures and drawing was difficult because she was not comfortable with this content herself. Traditional textbook exercises would not have had the same cognitive demand for Donna.

Element of Surprise

Donna assumed that Belinda would remember the converting-improper-fractions procedure Donna and her partner had taught her. She provided the review problems in the third session because she fully expected that Belinda would do them quickly and that they would then move on to other problems. Donna believed that children learn what has been taught them. When Belinda did not retain the procedure, Donna had to resolve this contradiction between her expectation and the outcome. One explanation would be that the teaching had been poor, but Donna had given the best explanation she could give and had seen that Belinda was able to use the procedure several times. Donna then developed another explanation for this unexpected phenomenon: Children do not always learn what has been taught. If the session had proceeded as Donna expected, without any surprises, Donna's existing belief system would not have been challenged.

Several other students in the MEFE course had similar experiences of trying to teach something only to find that their child had not learned it. Several students commented that this experience upset them and made them more aware of the how difficult these concepts were to learn. These conversations contributed to Donna's reflection on this new belief.

Donna's efforts to teach Belinda to convert improper fractions to mixed numbers could be characterized as a failed teaching experience. Weinstein (1990) suggested that failed teaching experiences were critical in helping preservice teachers to overcome their optimistic bias about their abilities as teachers. She speculated that preservice teachers needed to see that teaching was not as easy as they had believed and that facing the challenge of teaching remedial students would affect their beliefs.

When preservice teachers encounter challenging teaching situations, they begin to realize the importance of subject-matter knowledge. In an interview, Donna commented that she realized that she needed to know more than just the procedure, that she needed to understand the "why" in addition to the "how." She said that she had always liked mathematics and had never felt the need to know why, but for teaching she needed to know why so that she could better meet the needs of her students. If the interview in Session 3 had gone smoothly, I doubt that Donna would have come to this conclusion.

Emotionally Charged Experience

One of the critical features of Donna's work in the MEFE was the interpersonal component. Throughout the semester Donna proclaimed her love of children and her strong desire to be a teacher. Working with Belinda on fraction concepts provided Donna with an opportunity to connect with a child and to develop a relationship. This one-on-one teaching situation was intimate in that Belinda was asked to share her thinking and Donna was committed to listening. Goldstein (1999) wrote about this kind of interaction as involving both an intellectual component and an emotional component, requiring engagement and receptivity on the part of the teacher. This kind of engrossing experience has the emotional charge that I argued earlier engenders beliefs. Without the interpersonal aspect, I doubt that Donna's beliefs would have been affected.

Building on Existing Belief Systems

The belief change that I have attempted to illustrate focused on the elaboration of beliefs and beliefs' becoming connected in new ways. Donna's belief about children's confidence became connected to her beliefs about mathematics. She also developed a new belief that children do not always learn what has been taught. Her belief about teaching was elaborated when she added to it the notion that teachers should listen to children to determine at what point to begin instruction.

I argued earlier about the folly in trying to create paradigmatic shifts in preservice teachers' beliefs systems. I suggested that building on belief systems was the more prudent

course of action and the one we take in our IMAP work with our preservice teachers. By tapping into the preservice teachers' preexisting beliefs about the importance of caring in the act of teaching, we in IMAP were able to catalyze what we hope will be ongoing changes in belief systems both about mathematics and about teaching.

Donna realized that the work of teaching, in general, and the work of teaching mathematics, in particular, were more complicated than she had ever imagined. She recognized that her knowledge of mathematics needed to be deep and secure to enable her to listen to the child and make immediate decisions without having to second guess her own knowledge of the mathematics she and the child were exploring together. She also came to see that the work of caring was more complicated than she had anticipated. She noticed that being nice was insufficient to help a child develop the confidence that she began to believe was important in learning mathematics.

Donna did not change in all the ways for which we in IMAP had hoped, leaving us to wonder how we can change the MEFE to better address the procedural orientation of many preservice teachers. While Donna continues to consider children's confidence, she may come to see that children develop confidence in their own thinking when they generate their own approaches to solving problems rather than appropriating an approach their teacher shows them. This may be the connection that catalyzes further change in Donna's beliefs. We look forward to revising the MEFE so that it can have even more profound effects on students' beliefs.

References

Ball, D. (2000). Bridging practices: Intertwining content and pedagogy in teaching and learning to teach. *Journal of Teacher Education, 51*, 241–247.

Cooney, T.J., Shealy, B.E. & Arvold, B. (1998). Conceptualizing belief structures of preservice secondary mathematics teachers. *Journal for Research in Mathematics Education, 29*(3), 306 –333.

Feiman-Nemser, S., McDiarmid, G. W., Melnick, S., & Parker, M. (1988). *Changing beginning teachers' conceptions: A study of an introductory teacher education course*. East Lansing: National Center for Research on Teacher Education and Department of Teacher Education, Michigan State University.

Fenstermacher, G. (1979). A philosophical consideration of recent research on teacher education. In L.S. Shilman (Ed.), *Review of research in education* (Vol. 6, pp. 157 – 185).

Goldstein, L. (1999). The relational zone: The role of caring relationships in the co-construction of mind. *American Educational Research Journal, 36*, 647–673.

Goldstein, L., & Lake, V. (2000). Love, love, and more love for children: Exploring preservice teachers' understandings of caring. *Teaching and Teacher Education, 16*, 861-872.

Goodman, J. (1988). Constructing a practical philosophy of teaching: A study of preservice teachers' professional perspectives. *Teaching and Teacher Education, 4*, 121-137.

Green, T. F. (1971). *The activities of teaching*. New York: McGraw-Hill.

Hollingsworth, S. (1992). Learning to teach through collaborative conversation: A feminist approach. *American Educational Research Journal, 29*, 373–404.

Kuhn, T. (1996). The structure of scientific revolutions. Chicago, IL : University of Chicago Press.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Erlbaum.

Mack, N. (1995). Confounding whole-number and fraction concepts when building on informal knowledge. *Journal for Research in Mathematics Education, 26,* 422–443.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19,* 317–328.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62,* 307–332.

Rokeach, M. (1968). *Beliefs, attitudes, and values; A theory of organization and change.* San Francisco: Jossey-Bass.

Simon, M., Tzur, R., Heinz, K., Kinzel, M., & Smith, M. S. (2000). Characterizing a perspective underlying the practice of mathematics teachers in transition. *Journal for Research in Mathematics Education, 31,* 579-601.

Stake, R. (1995). *The art of case study research.* Thousand Oaks, CA: Sage.

Weinstein, C. S. (1990). Prospective elementary teachers' beliefs about teaching: Implications for teacher education. *Teaching and Teacher Education, 6,* 279–290.

Wideen, M., Mayer-Smith, J., & Moon, B. (1998). A critical analysis of the research on learning to teach: Making the case for an ecological perspective on inquiry. *Review of Educational Research, 68*(2) 130–178.

' beliefs.

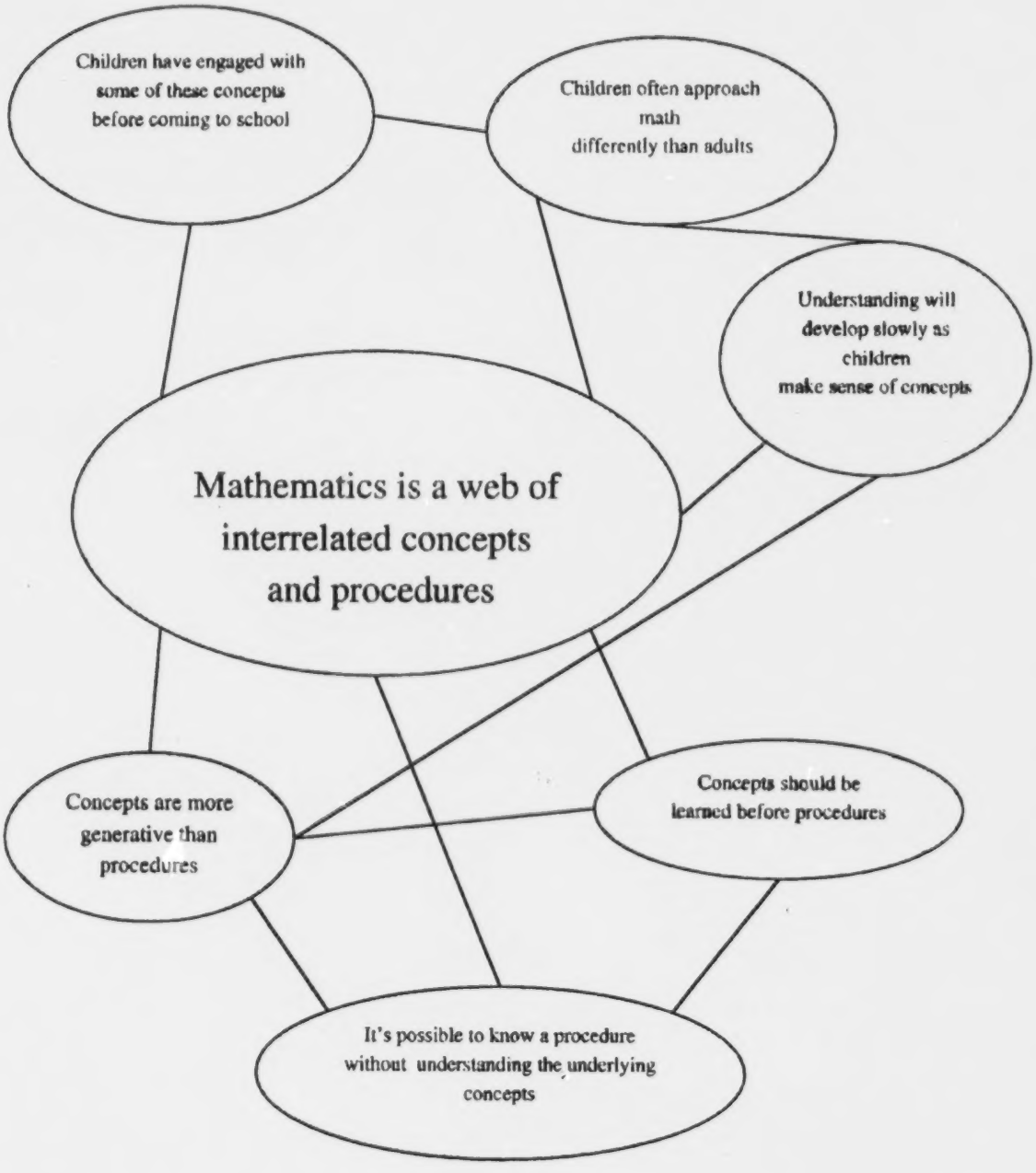
Children have engaged with some of these concepts before coming to school
Children often approach math differently than adults
Understanding will develop slowly as children make sense of concepts
Mathematics is a web of interrelated concepts and procedures
Concepts are more generative than procedures
Concepts should be learned before procedures
It's possible to know a procedure without understanding the underlying concepts

Figure 1. Ideal belief system.

BEST COPY AVAILABLE

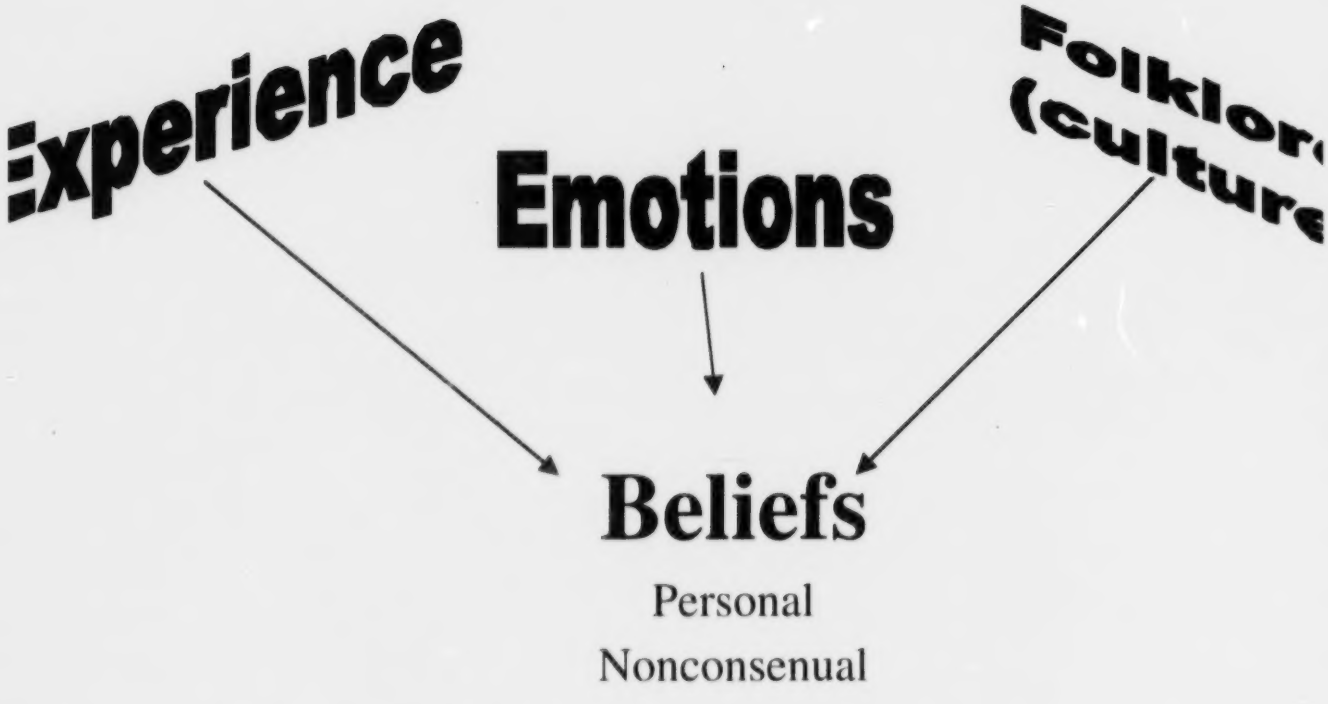

Figure 2. Sources of beliefs.